www.bircu-journal.com/index.php/birci
Budapest International Research and Critics Institute-Journal (BIRCI-Journal)
Humanities and Social Sciences
ISSN 2615-3076 Online)
ISSN 2615-1715 (Print)
Budapest Institute

Analysis on the Effectiveness of Personal Protective Equipment in Protecting Against Transmission of COVID-19 – A Systematic Review with Additional Insights on Vaccinated Population

Brenda Carolinsia
Faculty of Public Health, Universitas Indonesia
brendacarolinsia@gmail.com

Abstract

COVID-19 is transmitted through respiratory droplet through close contact. The risk of transmission is even higher in aerosol-generating procedures, as there are evidences that the disease could be transmitted airborne in these particular settings. Personal protective equipment remains the most effective way to prevent transmission of COVID-19. In this systematic review, we aim to synthesize data on the effectiveness of personal protective equipment in protecting against transmission of COVID-19. We also added additional insight the benefits of effective PPE use towards the hospital services, and on whether these protective measures should still be followed in post-vaccination population. We conducted a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Four internet databases were searched using predefined search terms. Narrative review was developed on the effectiveness of personal protective equipment in protecting against transmission of COVID-19. Out of initial 71 articles found using the predefined search terms, 8 studies fulfilled the inclusion criteria and were included in our final analysis. We found that face masks remain the most effective personal protective equipment against the transmission of COVID-19. Respirator masks such as the N95 mask offer better protection compared to regular cloth face mask, but is equal to or only to slightly better compared to surgical masks. Other effective protective equipment includes gowns, gloves, and eye protection such as face shields or goggles for aerosol-generating procedures. Face masks is highly effective in protecting against the transmission of COVID-19, with surgical mask and respirator mask provide better protection compared to cloth masks. Gowns, gloves, and eye protection were needed for aerosol-generating procedures. In a world with only a small number of people are vaccinated against COVID-19, it remains important that personal protective equipment should still be worn to prevent transmission.

Keywords
COVID-19; personal protective equipment; effectiveness; mask

I. Introduction

Since the World Health Organization (WHO) declared the Coronavirus Disease 2019 (COVID-19) as a pandemic in March 20201 COVID-19 cases kept soaring. As of June 2021, there were 178 million people infected with 3 million deaths.2 The disease is mainly transmitted through respiratory droplet. Droplet transmission can occur when a person is within 1 meter of someone with respiratory symptoms, exposing his/her mucosae or conjunctiva to respiratory droplets. Transmission may also occur through fomites in the immediate environment around the infected person. Airborne transmission of COVID-19 could also occur in certain circumstances and settings, especially in procedures or

treatments that generate aerosols, also known as aerosol-generating procedures (AGP). Organization must have a goal to be achieved by the organizational members (Niati et al., 2021). The success of leadership is partly determined by the ability of leaders to develop their organizational culture. (Arif, 2019).

To protect the general population and healthcare workers against the transmission of COVID-19, several precautionary actions have been proposed. This includes the use of personal protective equipment, particularly face masks for the general population, and additional surgical gowns, gloves, and eye protections for healthcare workers.4 This, when combined with other infection control measures such as hand hygiene and social distancing provides the optimal protection against the transmission of the SARS-CoV-2 virus.5,6 Although vaccination had been rolled out in many countries since January 2021, the current recommendation remains that COVID-19 safety measures should still be followed as they are effective as containment and protective measures.

Since safety measures in the form of personal protective equipment remains instrumental in the protection against COVID-19, there needs to be an evaluation of the effectiveness of such protective equipment in protecting against transmission. In this systematic review, we aim to synthesize data on the effectiveness of personal protective equipment in protecting the population against the transmission of COVID-19. We also provided additional insight on We also added additional insight the benefits of effective PPE use towards the hospital services and on whether personal protective equipment remain effective in protecting vaccinated populations against the disease.

II. Research Method

2.1 Design

This study is a systematic review conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol.

2.2 Search

Search for relevant literatures was conducted using several electronic databases; namely MEDLINE (PubMed), Google Scholar, SCOPUS and MedSci. The following keywords combinations were used in our search: (i) {"Covid-19" OR "SARS-CoV-2"} AND (ii) {"personal protective equipment" OR "PPEs" OR "protective equipment"} AND (iii) {"effectiveness"}. The following alternative search term was also used for additional references: (i) {"Covid-19" OR "SARS-CoV-2"} AND (ii) {"personal protective equipment" OR "PPEs" OR "mask" OR "face shield" OR "gown"} AND (iii) {"effectiveness"} AND (iv) {“vaccinated”}.

Articles published in English from January 2020 to June 2021 were included in our search, along with articles available for free in full text. We included all types of research such as systematic reviews, reviews, clinical trials, meta-analyses, and randomized clinical trials in our search to counter for the disadvantages of including only randomized clinical trial. Additionally, we conducted additional search on references used by articles found through electronic database, to expand our references.

2.3 Inclusion and Exclusion Criteria

Inclusion criteria for this systematic review include: (1) Articles published in English; (2) Articles were available for free in full text; (3) Articles published in January 2020 to June 2021; (4) Studies conducted on general population and healthcare workers;

(5) Study were conducted on the effectiveness of personal protective equipment against the transmission of COVID-19.

Articles not published fully in English, not published in January 2020 to June 2021, articles containing protocols, discussion, opinions, and editorial letters as well as articles not available free in full text, were excluded.

We conducted initial literature search on four databases, and the resulting articles were screened for duplication. After excluding duplicates, we subsequently screened the abstract and titles of the remaining articles for relevancy with our research question. Articles with titles and abstracts not relevant to our research question were subsequently excluded, and the remaining articles were reviewed in full text. Data extracted include study characteristics, research methods and design, and effectiveness of personal protective equipment against COVID-19 transmission.

2.4 Analysis

We used descriptive summary statistics to report the number of published studies. We presented our search result in a PRISMA diagram (Figure 1). All studies were analyzed descriptively, and the findings were synthesized.

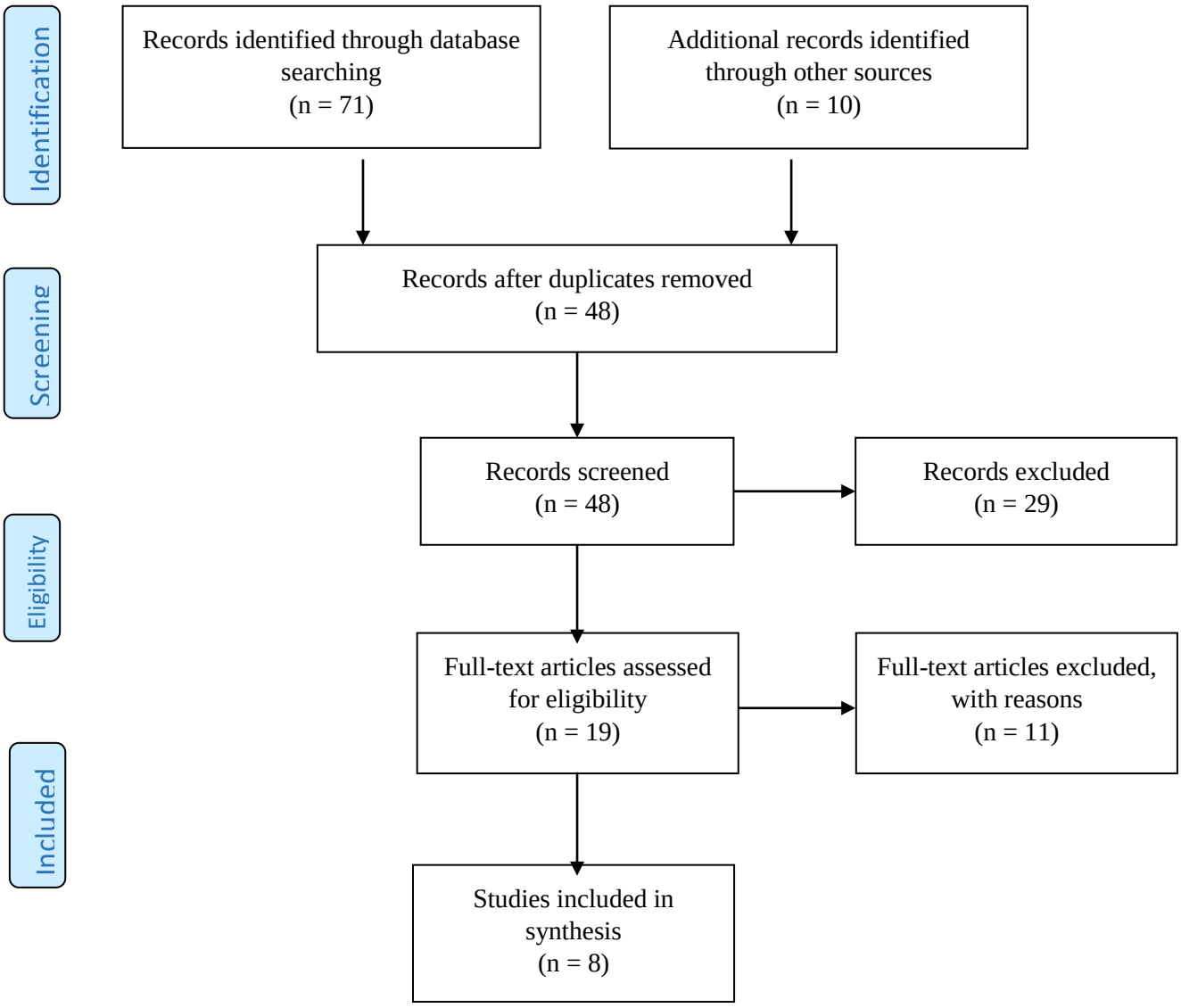

***Figure 1**. PRISMA Flow Chart*

III. Result and Discussion

A total of 71 articles were identified using the predetermined search keywords on four scientific journal databases. After screening for duplications, 33 articles were removed. We subsequently performed title screening to determine the articles' relevance to our research question, after which 29 articles were removed due to them being irrelevant to our research question. Full-text screening was performed on the remaining 19 articles, and 8 articles were included in the analysis.

3.1 Study Characteristics

Of 8 total articles reviewed and analyzed, the study designs of the eligible articles include literature reviews (n=3), systematic reviews (n=4), and meta-analysis (n=1). Countries where the articles originated include: United Kingdom, Italy, Germany, USA, Switzerland, France, Australia, and China (all n=1).

Findings were summarized in Table 1.

Table 1. Findings from eligible articles

Author/Year	Country	Sample Characteristics	Design	Effectiveness of PPE
Abboah-Offei *et al*., 2021[5]	UK	General population; subset of data on healthcare workers Non-vaccinated	Systematic Review	This study finds that the use of face mask and N95 mask is effective in reducing the transmission of COVID-19, with N95 being slightly better than regular face mask. The use of additional respirators is also effective in protecting HCW against COVID-19. When combined with hand hygiene, mask wearing significantly reduced the transmission for COVID-19
Ha, 2020[8]	Australia	Healthcare Workers Non-vaccinated	Literature review	Gown was found to be more protective than apron. Double gloving is better than single gloving. Surgical mask and N95 is equally effective in protecting against COVID-19. Use of additional PPAR respirator is better than PPE without respirator.
Hirschmann, *et al*., 2020[4]	Switzerland	Healthcare Workers; orthopedic surgical unit Non-vaccinated population	Systematic Review	PPEs in the form of mask, gown, glove, as well as eye protection with goggles or face shield are effective in protecting against COVID-19.

Author/Year	Country	Sample Characteristics	Design	Effectiveness of PPE
				Interestingly, this study also offer telemedicine as a form of ePPE that is effective in protection against COVID-19.
Kampf, *et al*., 2020[6]	Germany	Healthcare Workers Non-vaccinated	Literature review	Face masks is effective in reducing the risk of transmission of COVID-19. Gloves also protect against contamination through hand contact, but is associated with lower hand hygiene compliance. PPEs alone is less effective when compared to PPE plus infection control measures.
Li, *et al*., 2020[9]	China	General populations, Healthcare workers (HCW) as subgroup Non-vaccinated	Systematic Review and Meta-Analysis	Face masks significantly reduced the risk of transmission for COVID-19
Romano-Bertrand, *et al*., 2020[10]	France	Healthcare workers (HCW) Non-vaccinated	Literature review	The use of face mask significantly reduced the risk of contracting COVID-19.
Violante, *et al*., 2020[11]	Italy	General population Non-vaccinated	Systematic review	Surgical masks and N95 respirators provide equal protection against COVID-19 transmission.
Wang, *et al*. 2021[12]	USA	General population Non-vaccinated	Review	Wearing face masks has been shown in studies to effectively protects against the transmission of COVID-19

3.2 Data Synthesis

(1) Face Masks and N95 Respirators

All of the studies analyzed reported that face masks are effective for protecting the population against the transmission of COVID-19.[4–6,8–12] Abboah-Offei *et al*. in their systematic review reported that face masks, regardless of the type, is more effective in protecting against COVID-19 transmission compared to no face masks.[5] Wang *et al*. reported that the risk for contracting COVID-19 is 36.9 times higher compared to no

face masks.[12] Romano-Bertrand, *et al*. reported a decreased risk for SARS-CoV-2 infection with wearing face masks, with significant association (combined RR 0.12; 95% CI 0.06-0.27; p<0.000).[10] Li, *et al*. also reported that face masks could reduce SARS-CoV-2 transmission risk in general population (pooled OR 0.38 and 95% CI: 0.21-0.69 (I^2 = 54.1%). In the subgroup of healthcare workers, there is an even more significant protective effect (pooled OR 0.29 (95% CI: 0.18-0.44, I^2 = 11%).[9]

Furthermore, while studies have found that surgical face masks are better than cloth face mask in protecting against SARS-CoV-2,[5] data on whether surgical face mask is inferior to N95 respirator mask is mixed. Studies by Ha and Violante, *et al*. reported that surgical face mask and N95 respirators are equally effecting in preventing the transmission of SARS-CoV-2,[8,11] while Abboah-Offei *et al*. reported that N95 respirators are better than regular surgical mask in protecting against COVID-19.

When combined with infection control practices and other personal protective equipment, face masks may provide the optimal protection against the transmission of COVID-19.

(2) Other Personal Protective Equipment

Four of the studies analyzed also looked at other personal protective equipment, namely gloves, gowns, and eye protection (goggles and face shields). Ha reported that gowns were more effective in protecting against infection compared to simple aprons (MD -1.36, 95% CI -1.78 - -0.94).[8] Similarly, Hirschmann *et al*. also reported that in procedures that generate aerosols such as in operating theatres, surgical gowns could reduce infection and contamination risk. It provides protection against bodily fluid up to 3-8 m around the operating table.[4]

Ha also reported that gloves provided protection against contamination and transmission of infection through hand contact, and that double-gloving provided more protection compared to single-gloving (RR 0.36, 95% CI 0.16 – 0.78).[8] Risk of infection was reportedly lowered form 54% to 10% by double gloving.[4]

Hirschmann *et al*. also reported that the use of eye protection in the form of goggles and face shields ere effective in protecting against transmission of pathogens in aerosol generating procedures. Helmets is another option for protection against body spray, but it can only protect against airborne transmission of COVID-19 if combined with respirator masks.

Ha noted that while layers of PPEs provide protection against the transmission of SARS-CoV-2, it also adds to the complexity of care.

(3) ePPE – Telemedicine

Hirschmann *et al*. reported that telemedicine could be considered as a form of efficient electronic personal protective equipment for healthcare workers, especially in non-urgent settings. As these units face partial closure due to shifting focus to COVID-19 patients, They noted that telemedicine could be an efficient way to protect the healthcare workers from this unit while still being able to provide treatment for their patients in the safety of their own homes. Further, they recommended that in these settings, only patients with urgent condition should be seen in contact with proper PPEs, while other patient could be treated using telemedicine, protecting both the healthcare workers and patients from exposure to COVID-19.

3.3 Discussion

COVID-19 is mainly transmitted through inhalation of respiratory droplet between people in close contact of one another.[3,13] Studies have also reported airborne transmission in certain settings, particularly in aerosol-generating procedures (AGPs) and treatments. According to the WHO, this includes, but not limited to, "endotracheal intubation, administration of nebulized treatment, bronchoscopy, open suctioning, turning the patient to the prone position, disconnecting the patient from the ventilator, manual ventilation before intubation, tracheostomy, non-invasive positive-pressure ventilation, and cardiopulmonary resuscitation". Aerosol-generating procedures in surgical settings, such as the use of highspeed power tools, have a high risk of virus particles transmission from body fluids and pieces of body tissue. COVID-19 is known to be present in all body fluids.

Considering its mode of transmission, several personal protective equipment has been recommended as protection against COVID-19. Among these, the most commonly recommended is the use of face mask.[9] From the studies analyzed in this review, we found that the use of face mask significantly protects against the transmission of COVID-19. Cloth face mask is better than no face mask at all, but surgical mask and N95 respirators are superior to cloth face mask in terms of protection.[5,8] Data were mixed on whether N95 respirator masks are superior to surgical masks, with some studies citing equal effectiveness, while others reported N95 superiority.[5,8,11] Our findings are in line with previous studies that reported the effectiveness of cloth mask compared to no mask at all. Chugtai *et al*. reported that cloth face masks could provide some degree of protection when they are well-designed and worn correctly. However, surgical masks and N95 respirator masks provide better degree of protection compared to cloth face masks. Multi-layered masks have also been reported to provide a better degree of protection.

Our study also found that the use of face masks, whether surgical or N95, provides better protection when combined with other personal protective equipment, such as gowns, gloves, and eye protection (goggles and face shields). A previous study by Heinzerling *et al*. have also noted that personal protective equipment in combination with hand hygiene have significantly lowered the risk of transmission of COVID-19.[15] Wearing hand gloves have also been reported to reduce the risk of transmission, but hand gloves wearing were also associated with poorer compliance with hand hygiene, most likely due to the fact that healthcare workers felt that wearing gloves reduces the need to frequently wash hands.[4,16] Surgical gown and face shields are effective in protecting healthcare workers against transmission of COVID-19 through bodily fluids, as would often be the case in surgical settings.

Interestingly, one study by Hirschman *et al*. reported that telemedicine could be considered as an electronic personal protective equipment where it could protect healthcare workers and patients from unnecessary exposure due to hospital visits for elective and/or non-urgent care. This is in line with another study by Provenzano *et al*. who also reported that telehealth is an effective alternative way to ensure protection of patients and healthcare workers, especially in units providing elective and non-urgent care.[17] As these units face partial closure due to the shift of focus to COVID-19 patients, shifting to telemedicine and virtual care could provide additional protection for patients and healthcare workers alike.

From hospital management point-of-view, effective use of PPE especially against COVID-19 patients yielded numerous benefits. Effective use of PPE, in addition to proper infection control procedures, limits transmission from patients to healthcare workers. This in turn decreases the risk of understaffing, especially in times of surge during the pandemic. Opting to procure PPEs that are most effective against COVID-19 would also

be a more cost-efficient decision from the hospital management, as it prevents overuse and overorder.

Additionally, although no direct correlation can be made from previous literatures, effective use of PPE and effective infection control procedure, proper management of staffing and work-hours, and cost-efficient decision-making from the hospital management regarding effective PPEs to prevent overuse and overorder, all theoretically lead to a better quality of service. Since hospital quality of service is a key factor in determining the patients' trust and intent-to-revisit, effective use of PPE, especially when combined with proper infection control procedure, can also lead to increased patient's trust towards the hospital services. This will in turn increase their intent-to-revisit.[20] This is especially important for hospitals in the face of significant decrease in patient visit during the COVID-19 pandemic.[21] This has the potential of creating a positive feedback loop, where more effective use of PPE may lead to better infection control procedures, which improves the quality of service. This in turn will lead to increased patient trust and intent-to-revisit, which will eventually increase the number of patient visit, generating more income for the hospital which can be invested towards the procurement of rational and effective PPEs.

All these data, however, were from studies conducted on non-vaccinated people. We found no data on the effectiveness of personal protective equipment of vaccinated population.

As of January 2021, vaccination have been gradually rolled out to countries around the world. Vaccine such as the vaccines from Pfizer-BioNTech, Oxford-AstraZeneca, Sinopharm, and Gamaleya, have been used for mass vaccination across the world.[7] In Indonesia, several vaccines have been used for vaccination, including the Sinopharm and AstraZeneca vaccines. As of the writing of this review on June 2021, only around 10% of the world's population have been fully vaccinated against COVID-19. In Indonesia, the number was even smaller, at 4.6% of fully vaccinated people and 4.3% of people being partially vaccinated.

Considering that only a small number of people have been vaccinated against COVID-19, it is logical that personal protective equipment will still play a significant role in protection against COVID-19. Until a sufficient number of people is vaccinated and herd immunity is reached to protect those who cannot be vaccinated against COVID-19, it remains imperative that personal protective equipment protocols should be followed, in addition to other infection control measures.

IV. Conclusion

Face masks is highly effective in protecting against the transmission of COVID-19, with surgical mask and respirator mask provide better protection compared to cloth masks. Gowns, gloves, and eye protection were needed for aerosol-generating procedures. In a world with only a small number of people are vaccinated against COVID-19, it remains important that personal protective equipment should still be worn to prevent transmission.

References

Abboah-Offei M, Salifu Y, Adewale B, et al. (2021). A rapid review of the use of face mask in preventing the spread of COVID-19. Int J Nurs Stud Adv; 3: 100013.

Arif, S. (2019). Influence of Leadership, Organizational Culture, Work Motivation, and Job Satisfaction of Performance Principles of Senior High School in Medan City. Budapest International Research and Critics Institute-Journal (BIRCI-Journal). P.

239-254
Chughtai AA, Seale H. (2020). MacIntyre CR. Effectiveness of Cloth Masks for Protection against Severe Acute Respiratory Syndrome Coronavirus 2. Emerg Infect Dis; 26: e200948.
Fuller C, Savage J, Besser S, et al. "The Dirty Hand in the Latex Glove": A Study of Hand Hygiene Compliance When Gloves Are Worn. Infect Control Hosp Epidemiol 2011; 32: 1194–1199.
Griswold DP, Gempeler A, Kolias A, et al. Personal protective equipment for reducing the risk of COVID-19 infection among health care workers involved in emergency trauma surgery during the pandemic: An umbrella review. J Trauma Acute Care Surg 2021; 90: e72–e80.
Ha JF. (2020). The COVID-19 pandemic, personal protective equipment and respirator: A narrative review. Int J Clin Pract; 74. Epub ahead of print. DOI: 10.1111/ijcp.13578.
Heinzerling A, Stuckey MJ, Scheuer T, et al. (2020). Transmission of COVID-19 to Health Care Personnel During Exposures to a Hospitalized Patient - Solano County, California, February. MMWR Morb Mortal Wkly Rep 2020; 69: 472–476.
Hirschmann MT, Hart A, Henckel J, et al. (2020). COVID-19 coronavirus: recommended personal protective equipment for the orthopaedic and trauma surgeon. Knee Surgery, Sport Traumatol Arthrosc; 28: 1690–1698.
Kampf G, Brüggemann Y, Kaba HEJ, et al. 2020). J Hosp Infect; 106: 678–697.
Kim CE, Shin J-S, Lee J, et al. (2017). Quality of medical service, patient satisfaction and loyalty with a focus on interpersonal-based medical service encounters and treatment effectiveness: a cross-sectional multicenter study of complementary and alternative medicine (CAM) hospitals. BMC Complement Altern Med; 17. Epub ahead of print. DOI: 10.1186/s12906-017-1691-6.
Li Y, Liang M, Gao L, et al. Face masks to prevent transmission of COVID-19: A systematic review and meta-analysis. Am J Infect Control 2020; 1–7.
Liang M, Gao L, Cheng C, et al. (2020). Efficacy of face mask in preventing respiratory virus transmission: A systematic review and meta-analysis. Travel Med Infect Dis; 36. Epub ahead of print. DOI: 10.1016/j.tmaid.2020.101751.
Niati, D. R., Siregar, Z. M. E., & Prayoga, Y. (2021). The Effect of Training on Work Performance and Career Development: The Role of Motivation as Intervening Variable. Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences, 4(2), 2385–2393. https://doi.org/10.33258/birci.v4i2.1940
Our World in Data. (2021). Coronavirus (COVID-19) Vaccinations. 2021, https://ourworldindata.org/covid-vaccinations?country=IDN~OWID_WRL (accessed 23 June).
Provenzano DA, Sitzman BT, Florentino SA, et al. (2020). Clinical and economic strategies in outpatient medical care during the COVID-19 pandemic. Reg Anesth Pain Med; 45: 579–585.
Romano-Bertrand S, Carréa Y, Glélé L-SA, et al. How to address SARS-CoV-2 airborne transmission to ensure effective protection of healthcare workers? A review of the literature. Infect Dis Now.
Santana R, Sousa JS, Soares P, et al. (2020). The Demand for Hospital Emergency Services: Trends during the First Month of COVID-19 Response. Port J Public Heal; 38: 30–36.
Steuart R, Huang FS, Schaffzin JK, et al. (2020). Finding the value in personal protective equipment for hospitalized patients during a pandemic and beyond. J Hosp Med; 15:

295–298.
Su Z, Wen J, McDonnell D, et al. (2021). Vaccines are not yet a silver bullet: The imperative of continued communication about the importance of COVID-19 safety measures. Brain, Behav Immun - Heal; 12: 100204.
The World Health Organization. (2020). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March, https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020%0Ahttps://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19 (2020, accessed 20 June 2021).
The World Health Organization. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations (2020, accessed 22 June 2021).
The World Health Organization. WHO Coronavirus (COVID-19) Dashboard, https://covid19.who.int/table (2021, accessed 20 June 2021).
Violante T, Violante FS. (2020). Surgical masks vs filtering facepiece respirators for the protection against coronavirus infection: Current state of the art. Med del Lav; 111: 365–371.
Wang Y, Deng Z, Shi D. (2021). How effective is a mask in preventing COVID-19 infection? Med Devices Sensors; 4. Epub ahead of print. DOI: 10.1002/mds3.10163.
Zahar JR, Allaouchiche B. Even vaccinated against COVID-19, we must continue to wear a mask. Anaesth Crit Care Pain Med; 40.